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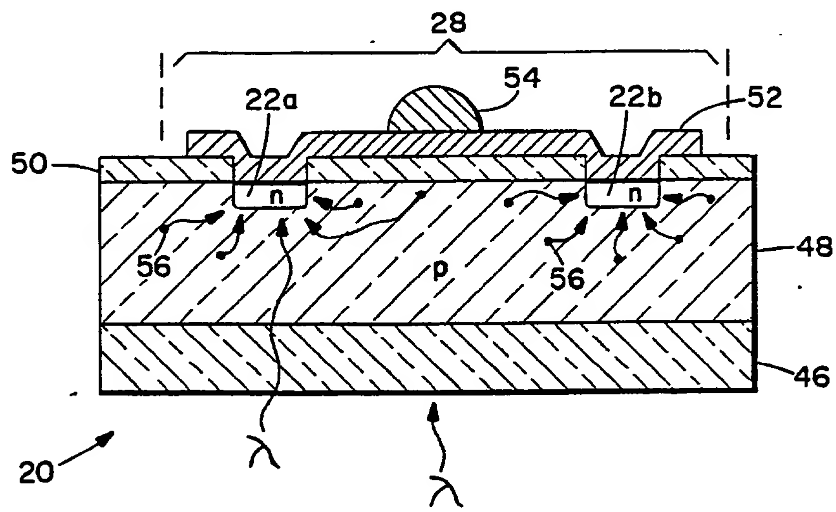

(57) Abstract

The pn-junction of a photodiode (20) is reduced in area to minimize the capacitance associated with the junction and increase the diode impedance. The reduction in junction area, and also the junction capacitance, is accomplished by subdividing the junction into a plurality of smaller junctions, or subjunctions (22a, 22b). The total area of the subjunctions is less than the area of a unitary, continuous area junction required for a corresponding desired optical area. The shape of each subjunction and the spacing between adjacent subjunctions is selected such that the lateral collection region around the periphery of each of the subjunctions overlap one another yielding an effective optical area of approximately the same size as a device having a single unitary, larger junction. Each of the plurality of subjunctions may be conductively coupled one to another by a layer of metallization (52) which is deposited such that it contacts each of the subjunctions. Each of the subjunctions may, alternatively, be conductively coupled one to another by being physically in contact.

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REDUCED AREA PHOTODIODE JUNCTION

FIELD OF THE INVENTION

The present invention relates generally to photodiodes and, in particular, relates to a photodiode having a pn-junction of reduced area.

BACKGROUND OF THE INVENTION

Photodectecors, such as photodiodes, are typically comprised of a volume of active photodetecting semiconductor material having a diode junction formed within a surface of the material. The junction typically collects charge carriers which are induced in the active region by the absorption of radiation. The junction collects carriers generated beneath the junction and also carriers generated outside the junction periphery. This collection process is typically facilitated by the diffusion of the carriers through the active region and into the junction. Due to the collection of photocarriers from the periphery of the junction an optically sensitive region associated with the junction extends laterally outward from the junction such that the optically sensitive region is generally larger than the junction area itself. The outermost extent of this lateral, or peripheral, collection region is a variable, and depends on the temperature of the semiconductor material, the doping concentration of the semiconductor material and other factors.

In general, it is desirable to make the junction area as small as possible to reduce the capacitance associated with the junction and also to increase the impedance of the junction. As can be appreciated, this reduction in junction capacitance results in an increased operating speed of the photodiode. Such an increase in speed may be especially desirable in focal plane array detectors wherein a plurality of pn-junctions, or photodiodes, are formed as a regular two-dimensional array over the surface of a layer of radiation-absorbing semiconductor material. The photodetecting material may be a layer of mercury-cadmium-telluride (HgCdTe) which is grown upon a cadmium-telluride (CdTe) substrate. In such a device the incident radiation to be detected may enter the device through the substantially transparent substrate, the radiation passing through the substrate and into the overlying layer of HgCdTe where the radiation is absorbed, thereby generating charge carriers. These charge carriers diffuse through the active HgCdTe layer until they are captured by one of the plurality of diode junctions formed upon an upper surface of the HgCdTe layer. Each of the photodiode junctions is coupled to detector circuitry which may scan the array of photodiodes in a row or column type fashion at a relatively high scanning rate. An increase in impedance, or diode resistance, is desirable in that it tends to increase the signal-to-noise ratio of the photodiode.

However, a problem is created when the area of the junction is decreased in that the aforementioned lateral collection area is also correspondingly

decreased, resulting in an overall decrease in the total volume of the diode photodetecting region and a consequent reduction in diode output signal magnitude.

SUMMARY OF THE INVENTION

The foregoing problem is overcome and other advantages are realized by a photodiode constructed in accordance with the invention.

In one illustrative embodiment of the invention, the pn-junction area of a photodiode is reduced in area to minimize the capacitance associated with the junction and increase the diode impedance. The reduction in junction area is accomplished by subdividing the junction into a plurality of smaller junctions, or subjunctions, the total area of which is less than the area of a unitary junction required for a corresponding desired optical area. The shape of each subjunction and the spacing between adjacent subjunctions is selected such that the lateral collection region around the periphery of each of the subjunctions overlap one another yielding an effective optical area of approximately the same size as a device of the prior art having a single unitary, larger junction. Each of the plurality of subjunctions may be conductively coupled one to another by a layer of metallization which is deposited such that it contacts each of the subjunctions.

In accordance with another embodiment of the invention, a desired optical area is achieved by a unitary pn-junction which is reduced in area over a

corresponding junction of the prior art while yet providing for the collection of charge carriers from an approximately equally sized region. The reduced area unitary junction may be constructed as a plurality of physically interconnected subjunctions each of which has a predetermined shape and a spacing one from the other such that the lateral collection area surrounding each subjunction overlaps, thereby yielding an active area of a desired size.

In accordance with a method of the invention the capacitance of a photodiode pn-junction is reduced by determining a required size of an optical area for a given application, determining the area size of a continuous, unitary junction that will provide the determined optical area and subdividing the determined area of the junction into a plurality of smaller subjunctions each of which has a shape and a spacing one from another for defining a continuous lateral charge carrier collection area which is substantially equal to the predetermined size of the optical area. Inasmuch as the total area of the subjunctions is less than that of the continuous junction, for the determined optical area, the capacitance of the resulting junction is decreased.

BRIEF DESCRIPTION OF THE DRAWINGS

The following aspects of the invention will become more apparent in conjunction with the following detailed description of the invention taken in conjunction with the accompanying drawings wherein:

Fig. 1 shows a top view of a conventional photodiode having an optical area and a unitary, relatively large junction area formed therein;

Fig. 2 is a cross-sectional view of the photodiode of Fig. 1 taken along the line 2-2;

Fig. 3 shows a top view of a photodiode junction having, in accordance with one embodiment of the invention, a pair of side by side disposed elongated subjunctions having overlapping optical areas;

Fig. 4 shows a top view of four substantially circular subjunctions which are disposed such that their respective peripheral collection areas overlap to form an optical area having an area substantially equal to that to the device of Fig. 1;

Fig. 5 shows a top view of a photodiode having a junction which, in accordance with another embodiment of the invention, is comprised of substantially linear subjunctions interconnected in a rectangular fashion for defining an optical area of a size substantially equal to the photodiode of Fig. 1;

Fig. 6 shows a top view of another embodiment of a unitary, reduced area photodiode junction having an associated optical area which is similar in size to the device in Fig. 1;

Fig. 7 is a cross-sectional view of a photodiode, taken along the line 7-7 of Fig. 2, showing subjunctions formed within a layer of photodetecting material and a

layer of metallization which conductively couples the subjunctions one to another; and

Fig. 8 is a top view of a portion of an array of photodiodes, each of the photodiodes being comprised of a plurality of subjunctions.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to Figs. 1 and 2 there is shown a conventional photodiode 10 having a pn-junction 12 and a corresponding surrounding optical area 14. The size of the optical area 14 is related to the area of the junction area itself and also to the furthest extent of a lateral collection of charge carriers by the junction around the periphery of the junction. The junction also collects charge carriers generated in a region of active material which is below the junction area 12. The actual size of the optical area 14 is related to several factors, such as the doping concentration of the active semiconductor material, the temperature of the semiconductor material and other factors.

As can be seen in Fig. 2 the photodiode 10 may be comprised of a substrate 16 having a layer of photodetecting semiconductor material 18 deposited thereon. The layer 18 may be formed by a number of well known methods, such as by vapor or liquid phase deposition upon the supporting substrate 16. The substrate 16 may be comprised of CdTe which is substantially transparent to wavelengths of radiation of interest. The layer 18 may be comprised of HgCdTe which absorbs these wavelengths of interest thereby

generating photocarriers 20 which are collected by the junction 12. This collection is typically due to the charge carriers, which may be holes or electrons depending on a type of doping impurity within the layer 18, diffusing to the oppositely doped junction. Not shown in Fig. 2 is the interconnection between the junction 12 and detector circuitry which detects the presence of these collected charge carriers to generate a photodiode output signal. In order to form a pn-junction the layer 18 is typically doped with a p or an n type of dopant and the junction is doped with a dopant having the opposite electrical characteristic. In Fig. 2 it can be seen that the layer 18 is doped with a p type dopant and the junction 12 is doped with an n type dopant.

As can also be seen in Fig. 2, the optical area 14 extends beyond the periphery of the junction 12, this being due to the lateral diffusion of the charge carriers 20 along the periphery of the junction 12. Thus, the photoactive detecting region has a volume which includes not only the volume of the layer 18 immediately beneath the junction 12 but also a portion of material surrounding the periphery of the junction 12. The outermost extent of the optical area 14, as has been stated, is dependent upon several factors such as the doping concentration of the layer 18 and the junction 12 and also upon the temperature of the semiconductor material within the layer 18.

As has been previously stated, in order to reduce the capacitance associated with the pn-junction and also to increase the impedance of the junction it is desirable

to minimize the surface area of the junction 12. However, as this surface area of the junction 12 is decreased the associated optical area 14 is correspondingly decreased, thereby resulting in a reduced electrical signal being generated by the photodetector.

Referring now to Fig. 3 there is shown a portion of a diode 20 having, in accordance with one embodiment of the invention, a pair of subjunctions 22a and 22b which have a predetermined shape and spacing therebetween such that an optical area 24a and 24b, respectively, of each has an overlap region 26. The optical area 24 of each subjunction 22 is in part determined by the lateral collection of photocarriers from the periphery of each of the subjunctions 22. Thus, this overlap region 26 is a region where the optical area 24 of each subjunction 22 overlaps such that a charge carrier generated within the overlap region 26 may diffuse to either of the subjunctions 22a or 22b. This overlap between subjunctions 22a and 22b results in an effective total optical area 28 which is the sum of both optical areas 24a and 24b minus the area of the overlap region 26. Thus, the optical area 28 may be substantially equal to the optical area 14 of Fig. 1. However, the total of the areas of subjunctions 22a and 22b is less than the junction area 12 of Fig. 1. This reduction in overall junction area beneficially reduces the capacitance associated with the junction and increases the impedance of the junction. This decrease in junction capacitance results in, for example, the photodiode 20 having a faster response time to incident radiation than the photodiode 10 of

Fig. 1. The increase in junction impedance results in the diode 20 having a higher signal-to-noise ratio than the diode 10 of Fig. 1.

The elongated shape of each of the subjunctions 22a and 22b is but one possible shape for achieving this beneficial reduction in junction area. Referring now to Fig. 4 there can be seen a diode 30 which is comprised of four substantially circular subjunctions 32a through 32d, each of the junctions 32 having an active optical area 34a through 34d. The spacing between subjunctions 32 is such that the individual optical areas 34 overlap to form an overall optical area 36 which may be similar in size to the optical area 14 of Fig. 1. However, the total junction area, which is the sum of the individual areas of the subjunctions 32, can be seen to be substantially less than the junction area 12 of Fig. 1.

As can be appreciated, there are a number of possible shapes and spacings of subjunctions which will yield a total junction area having an associated effective optical area which is substantially equal to a desired optical area, such as the area associated with a conventional device having a single relatively large, junction area, while yet providing a reduction in total junction area.

In general, the minimum size of a junction is determined by the lower limits of photolithography, photolithography being one widely utilized method of constructing such junctions. Currently available photolithographic techniques may be employed to yield

subjunctions having a minimum dimension of 1 micron or even less.

In accordance with the invention, such a pn-junction comprised of a plurality of smaller subjunctions may have each of the subjunctions conductively coupled together by a layer of metallization which is deposited such that each of the subjunctions is contacted. This aspect of the invention will be described in detail hereinafter.

Referring now to Fig. 5 there is shown, in accordance with another embodiment of the invention, a photodiode junction having a reduced surface area which comprises a unitary junction 38 having a smaller junction area than the conventional junction of Fig. 1 while yet providing for a substantially equal optical area 40. As can be seen in Fig. 5, the junction 38 is comprised of a plurality of linear subjunctions 39a-39d interconnected to form a junction having a substantially rectangular outline. The width of each subjunction 39 and the spacing between oppositely disposed subjunctions is predetermined such that the overlap of the optical areas of each of the subjunctions 39 yields an effective optical area 40 which is substantially equal to the desired optical area.

Fig. 6 shows yet another junction 42 which is comprised of three linear subjunctions 43a-43c, two of which are similar to the junctions 22a and 22b of Fig. 3, connected together by a third subjunction to form the unitary junction 42. The resulting optical area 44 can

be seen to be substantially equal to the optical area 14 of Fig. 1 while the total junction area of the junction 42 is substantially less than the junction area of the junction 12 of Fig. 1.

It should be realized that a number of different shapes of junctions may be employed to yield an optical area having a desired size. Therefore, the invention is not meant to be limited to only the embodiments shown herein.

Referring now to Fig. 7 there is shown in cross-section an example of the photodiode 20 of Fig. 3. As can be seen, the photodiode 20 is comprised of a substrate 46 which may be substantially transparent CdTe. Overlying this substrate layer is a radiation absorbing layer of HgCdTe which may have a thickness of from 1 to 20 microns. Formed within an upper portion of the layer 48, to a typical depth of 0.5 microns, are the subjunctions 22a and 22b. As can be seen, the layer 48 is doped with a p-type material while the subjunctions 22 are doped with an n-type material.

In the embodiment shown in Fig. 7 the layer 48 may be doped with arsenic or may comprise native acceptors. The doping concentration of arsenic may be within a range of from approximately 2×10^{15} to approximately 5×10^{17} acceptor atoms per cubic centimeter. Each of the subjunctions 22 may be formed by ion implantation into an upper surface of layer 48 of an n-type donor material, such as boron, or by implant or other process damage which is n-type, to a concentration of approximately 10^{16} to 5×10^{17} atoms per cubic

centimeter. The n-type subjunctions 22, instead of being ion implanted, may be diffused into the surface region of the layer 48. Of course, the layer 48 may be doped with an n-type donor material and the subjunctions 22 may be a p-type acceptor material. In either case, the interface between each of the subjunctions 22 and the layer 48 forms a pn-junction, or a diode junction. Overlying the upper surface of the radiation absorbing layer 48 may be a passivation layer 50 comprised of, typically, silicon oxide, native oxides, or a wide bandgap semiconductor such as CdTe or CdS. The passivation layer 50 serves to both electrically insulate the layer 48 and to also control the surface states of the layer 48 to reduce thermal and other noise sources. Formed over the passivation layer 50 is a layer of metallization 52 which is deposited in a conventional manner, such as by evaporation, such that each of the junctions 22 is contacted by the metallization 52. In order to contact each of the junctions 22 a mask may be employed during the formation of the passivation layer 50 such that the passivation layer 50 does not cover the junctions 22. Metallization layer 52 may comprise aluminum, gold or any metal suitable for forming electrical continuity between the junctions 22. In order to interface the junctions 22 to suitable readout circuitry, such as a high speed multiplexer and detector, an indium "bump" may be formed upon the metallization layer 52. The bump 54 has a shape suitable for contacting an overlying conductor (not shown) on a readout device (not shown). Alternatively, metallization layer 52 may be formed to provide a pad for wire bonding the detector to a readout device.

It should be pointed out that if a plurality of physically separated subjunctions are employed, such as in Fig. 4, the metallization will typically be deposited such that it conductively contacts each of the subjunctions. If the physically joined subjunctions are employed, such as in Fig. 5, the metallization may need to conductively contact only one point along the subjunction. However, for some subjunction geometries the series resistance of the junction may be beneficially reduced by conductively contacting, with the metallization, one or more of the subjunctions at a plurality of points.

As can be seen in Fig. 7, radiation enters the bottom surface of the substrate 46, passes through the substrate 46 and is absorbed within the layer 48 thereby generating photocarriers 56. As can be seen, photocarriers 56 are collected by the subjunctions 22 both from the volume of radiation absorbing material in layer 48 which is directly beneath the subjunctions and also from that portion of the layer 48 which is laterally adjacent to the periphery of the subjunctions 22. Also, photocarriers 56 which are generated in a region between the two subjunctions 22 are also efficiently collected. Thus, it can be seen that the optical area 28 of the photodiode 20 has a greater extent than the area of the subjunctions themselves. Furthermore, it can be seen by comparing Fig. 7 to Fig. 2 that the optical area 28 is substantially equal to the optical area 14 while yet having a greatly reduced junction area. This reduction in junction area results in the aforedescribed beneficial reduction in junction capacitance and in the increase in junction impedance.

In general, the reduction in junction capacitance scales in a proportional manner to the reduction in junction area, however, depending upon the particular shape of the subjunction chosen, the reduction in capacitance may not be a linear function in that the perimeter of the subjunction may scale at a lesser rate than the scaling of the area.

Referring to Fig. 8 there is shown a portion of an array of photodiodes 62 each of which is formed on a common layer 64 of radiation absorbing material. Such an array, such as a focal plane array, has individual photodiodes disposed in an ordered two dimensional array organized into rows and columns. In accordance with the invention, each of the individual photodiodes 62 has a reduced area pn-junction comprised of a plurality of subjunctions 66, such as is depicted in Fig. 4. An active area 68 associated with each set of four subjunctions has an area predetermined for detecting radiation in accordance with a given application. Not shown in Fig. 8 is a passivation layer upon the surface of layer 64 and the metallization which conductively couples together each group of four subjunctions for coupling each group to a photodiode multiplexer, detector and readout circuit, it being understood that the passivation and metallization layers are similar to that shown in Fig. 7.

Although the various embodiments of the present invention have been described in the context of a HgCdTe type of photodiode it should be realized that the use of the invention may be advantageously employed

in photodetectors constructed of materials other than HgCdTe. For example, an indium antimonide (InSb) photodiode may also advantageously employ the reduced junction area of the invention. Similarly, other types of radiation detecting materials which are suitable for forming pn-junctions may also advantageously make use of the teaching of the invention.

Thus, the invention is not to be considered limited to the embodiments described heretofore and as depicted in the drawings, the invention is instead meant to be limited only as defined by the appended claims.

CLAIMS

What is claimed is:

1. A photodiode comprising:

a layer of radiation absorbing semiconductor material having means responsive to absorbed radiation for generating charge carriers within said layer; and

a diode junction formed within a top surface of said layer, said junction collecting said charge carriers for coupling said charge carriers to a detecting means, said junction collecting said charge carriers from at least a portion of said layer surrounding said junction, said surrounding portion defining a photodiode optical area, said junction comprising a plurality of diode subjunctions disposed relative one to another such that an optical area associated with each of said subjunctions overlaps an optical area associated with at least one other subjunction for defining said photodiode optical area.

2. A photodiode as defined in Claim 1 wherein said layer is doped with a first type of dopant and wherein each of said subjunctions is formed by doping a surface region of said layer with a second type of dopant.

3. A photodiode as defined in Claim 2 further comprising a supporting, substantially transparent substrate underlying said layer.

4. A photodiode as defined in Claim 3 wherein said substrate is disposed such that the radiation enters a surface of said substrate, passes through said substrate and is absorbed in said layer.

5. A photodiode as defined in Claim 4 further comprising:

means for insulating said top surface, said insulating means having openings made therethrough for exposing said subjunctions; and

means for conductively coupling said subjunctions to an external circuit means, said coupling means contacting said subjunctions through said openings.

6. A photodiode as defined in Claim 5 wherein each of said subjunctions are conductively coupled one to another by being physically joined one to another.

7. A photodiode as defined in Claim 5 wherein each of said subjunctions are conductively coupled one to another by being contacted by said coupling means.

8. A photodiode as defined in Claim 7 wherein each of said subjunctions has a substantially circular shape.

9. A photodiode as defined in Claim 7 wherein each of said subjunctions has a substantially elongated bar-like shape.

10. A photodiode as defined in Claim 6 wherein at least two of said subjunctions have an elongated linear shape, each being joined to the other by a third subjunction.

11. A photodiode as defined in Claim 6 wherein each of said subjunctions has an elongated substantially linear shape, each of said subjunctions being joined at opposing ends thereof to an end of another of said subjunctions.

12. A method of reducing the capacitance of a photodiode pn-junction, the photodiode having a predetermined size of an optical area associated with the lateral collection of charge carriers by a periphery of the junction, comprising the steps of:

determining the size of the optical area;

determining the area size of a junction which will provide the determined optical area, the area size of the junction having a first value of junction capacitance associated therewith; and

subdividing the determined area of the junction into a plurality of smaller subjunctions having a total area which is less than the determined area, each of the subjunctions having a shape and a spacing therebetween for defining a continuous lateral charge carrier collection area which is substantially equal to the predetermined size of the optical area whereby the sum of the capacitance of each of the subjunctions is equal to a second value of junction capacitance which is less than the first value.

13. A method as defined in Claim 12 further comprising the step of:

conductively coupling each of the subjunctions one to another.

14. A method as defined in Claim 13 wherein the step of conductively coupling is accomplished by contacting each of the subjunctions with a common conductor.

15. A method as defined in Claim 13 wherein the step of conductively coupling is accomplished by physically contacting each of the subjunctions one to another.

16. A photodiode comprising:

a substrate;

a layer of radiation absorbing semiconductor material overlying said substrate and being operable for generating charge carriers from absorbed radiation, said absorbing layer being doped with a first type of dopant to a first concentration;

a plurality of regions being doped with a second type of dopant to a second concentration formed within a top surface of said absorbing layer, each of said regions being disposed relative to one another for defining a photodetector diode pn-junction having a total lateral charge carrier collection area which is related to the total of the lateral charge carrier collection areas of each of said regions;

an insulating layer overlying said top surface, said insulating layer having at least one opening made therethrough for

exposing at least one of said plurality of regions; and

a conductor overlying said insulating layer for conductively contacting at least one of said regions through said opening.

17. A photodiode as defined in Claim 16 wherein said absorbing layer is comprised of HgCdTe, and said substrate is comprised of CdTe.

18. A photodiode as defined in Claim 17 wherein said absorbing layer is doped with arsenic or other p-type dopant or is p-type due to Hg vacancies and wherein each of said doped regions is doped with boron or other n-type dopant or is made n-type by ion implant or other process damage.

19. A photodiode as defined in Claim 17 wherein said absorbing layer is doped with boron or other n-type dopant or is made n-type by ion implant or other process damage and wherein each of said doped regions is doped with arsenic or other p-type dopant or is p-type due to Hg vacancies.

20. A photodiode as defined in Claim 16 wherein each of said doped regions is physically isolated from said other regions and wherein said conductive layer contacts each of said doped regions for conductively coupling together each of said regions.

21. A photodiode as defined in Claim 16 wherein each of said doped regions is in physical contact with each of said other regions.

FIG. 1
PRIOR ART

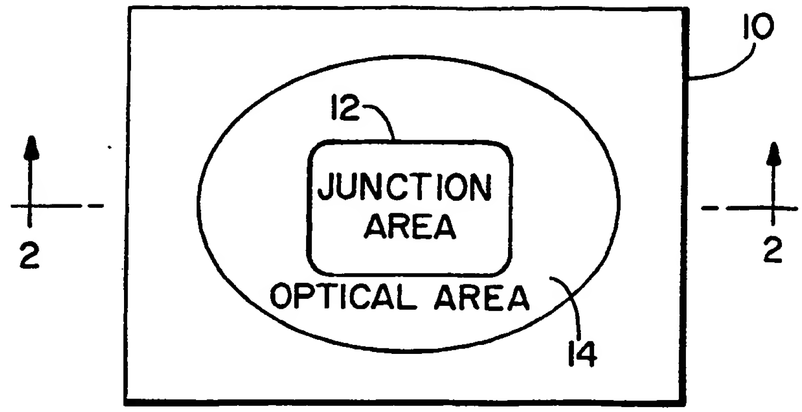


FIG. 2
PRIOR ART

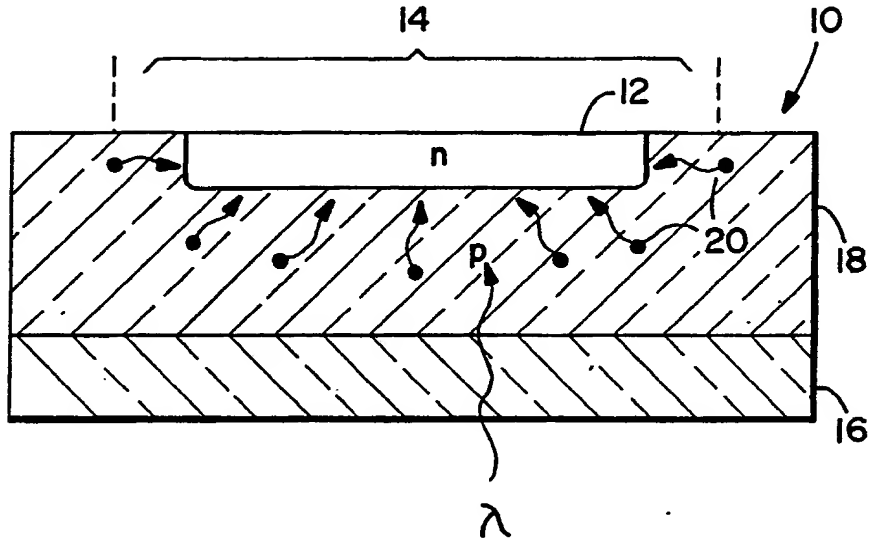


FIG. 3

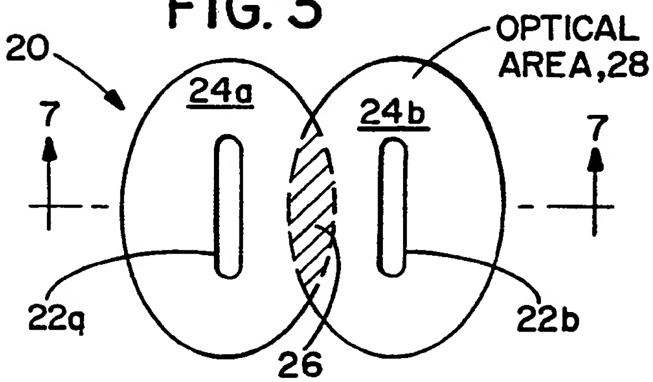


FIG. 4

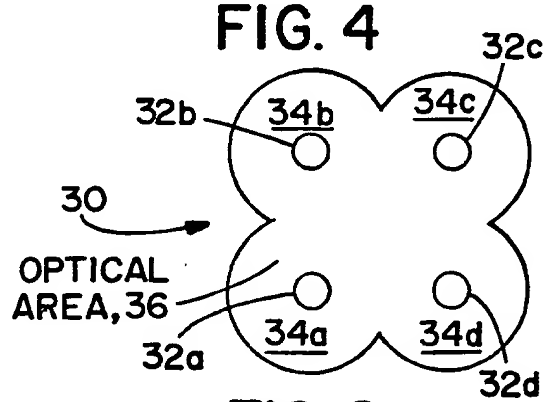


FIG. 5

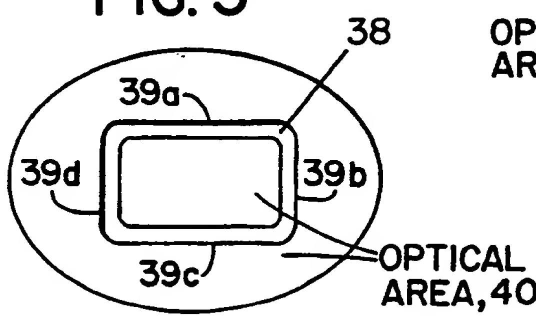


FIG. 6

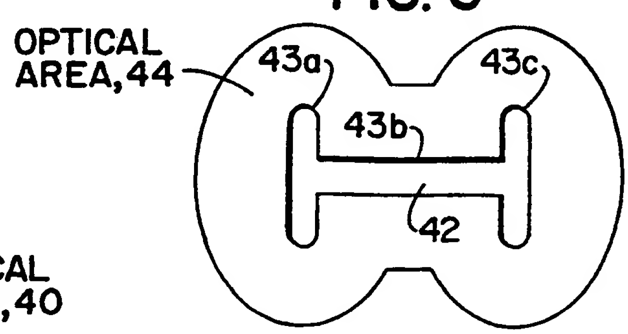


FIG. 7

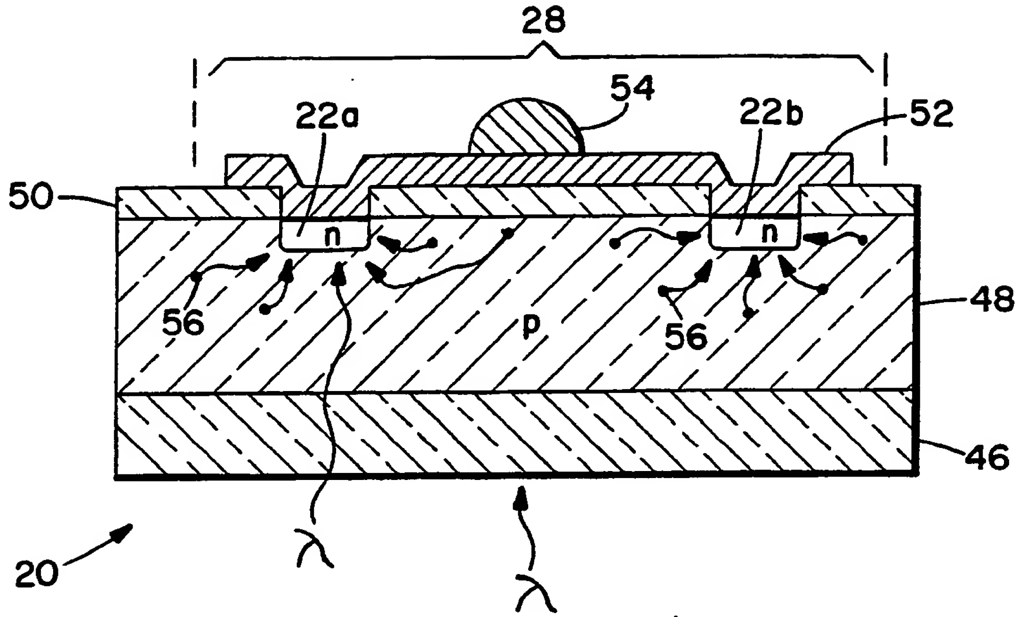
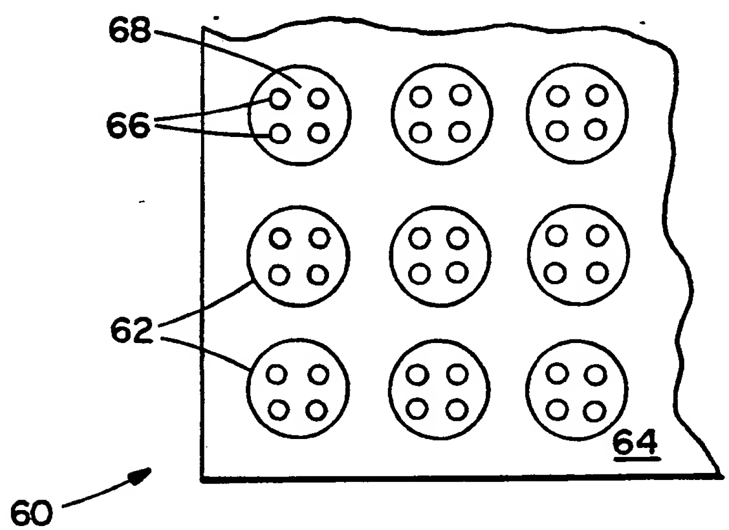


FIG. 8



INTERNATIONAL SEARCH REPORT

International Application No PCT/US 88/03583

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC^4: H 01 L 31/02; H 01 L 31/10

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC^4	H 01 L

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	DE, A, 2813671 (FORD-WERKE AG) 12 October 1978, see page 14, line 30 - page 19, line 2; page 20, lines 1-8; page 22, lines 6-29; page 23, line 7 - page 24, line 10; page 24, line 22 - page 25, line 23; page 34, line 28 - page 36, line 25; figures 1a,1b,2a,2b,3a,3b, 6a,6b,6c --	1-18,20,21
X	Patent Abstracts of Japan, vol. 8, no. 256, (E-280)(1693) 22 November 1984 & JP, A, 59127883 (MATSUSHITA DENSHI KOGYO K.K.) 23 July 1984, see the whole document --	1,2,6,7,9, 10,12-16,20, 21
X	N.T.I.S. Tech Notes, no. 10, Part B, October 1985 (Springfield, Virginia, US) J.T. English: "Solar cells with multiple small junctions", page 1169, see the whole document --	1,2,5,7,8, 12,13,14, 16,20

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* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
23rd February 1989	[illegible]
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	P.C.G. VAN DER PUTTEN

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III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FR M THE SEC ND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
X	Patent Abstracts of Japan, vol. 6, no. 176 (E-130)(1054) 10 September 1982 & JP, A, 5792877 (OKI DENKI KOGYO K.K.) 9 June 1982, see the whole document --	1,2,5,9,12, 16
A	Nachrichtentechnik Elektronik, vol. 32, no. 3, 1982 (Ost-Berlin, DD) G. Dittmar et al.: "Herstellung von CdHgTe-Infrarotdioden durch Ionenimplantation", pages 108-110 see the whole document	17-19

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. US 8803583

SA 25481

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE-A- 2813671	12-10-78	JP-A- 53123092	27-10-78
		GB-A- 1597538	09-09-81

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